Chapter 13
Technology Assessment in Systems Analysis

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Abstract In every age cumulative innovation accrue from the previous period, which discarded are those that do not meet the new challenges of civilization. Industrial Era brought a "mass society" and bureaucratic organizations. Information Era and emerged "information society" and network and virtual organizations. Always one of the sources of social change was the development of technology: the good and the bad. Therefore, multidimensional (multicriteria multiattribute) systems analysis is required, which is an important element of the valuation of real and potential technologies.

Keywords Systems analysis · Evaluation · Technology assessment

Introduction

Observation of the effects of technological development brings the need for evaluation, such as analysis and evaluation, in order to obtain useful knowledge in systems analysis as the basis of rational decisions. Rationalism in the research system implies the need to formulate both ex post and ex ante in order to anticipate future states and the design and development decisions. If you cannot predict systemic change (development) system, it should be the future shape so as to minimize the likelihood of possible side systems. Adoption of global and holistic perspective of the system seems to be obvious. Difficulties, however, concern the construction of modern instruments of research and description including (Sienkiewicz 1985):

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L.W. Zacher (ed.), *Technology, Society and Sustainability*,
DOI 10.1007/978-3-319-47164-8_13

- description language with correct terminology and categories,
- methods of observation of phenomena and processes,
- meters properties and attributes of objects (systems, processes),
- methods for the identification of the cause–effect relationship,
- model systems (structure and dynamics of process).

When structured empirical material is rich enough and efficient enough, instruments are efficient for:

- diagnosis (e.g., the degree of impact of technology on social development),
- comparison of the predicted effects of technology development in distinguished areas of society,
- technology to identify attributes that contribute to obtain a higher quality of life,
- predict social impact of socioeconomic development (Sienkiewicz 1983).

Failures related to "strict" forecast of social systems development meant that more important than the absolute accuracy of the specific predictions is to achieve social consensus of strategic directions of system development (the state). Thus, scenarios and techniques such as Delphi method, supported the need for simulation models, are an essential tool for predictive analysis. However, more often "forecasting" is replaced by the "foresight" which could mean an analysis by creating a social vision of the future that is likely to become "self-fulfilling forecast." (Sienkiewicz and Świeboda 2008)

On the other hand, evaluation studies of science and technology are conducted in the context of the impact of specific policies and scientific and technical use of the method called as Technology assessment (TA). Using both elements of "forecasting" and TA, evaluation methodology of technologies in the systems analysis of socioeconomic development has been developed (Table 13.1, Fig. 13.1).

Table 13.1 Technology assessment – nine primary sources (impacts) and benefits (outputs) of social development

	Development resources	Aspects of development	Consequences
1	Society	Sociology	Changes in quality of life
2	Economy	Economic	Changes in welfare
3	Policy	Politological	Changes in state power
4	Education	Educational	Changes in intellectual capital
5	Science	Cognitive	Changes in knowledge
6	Culture	Cultural	Changes in cultural identity
7	Energy	Energetic	Changes in the level of energy security
8	Natural environment	Ecological	Changes in the ecosphere
9	Information infrastructure	Informative	Changes in the value of information assets

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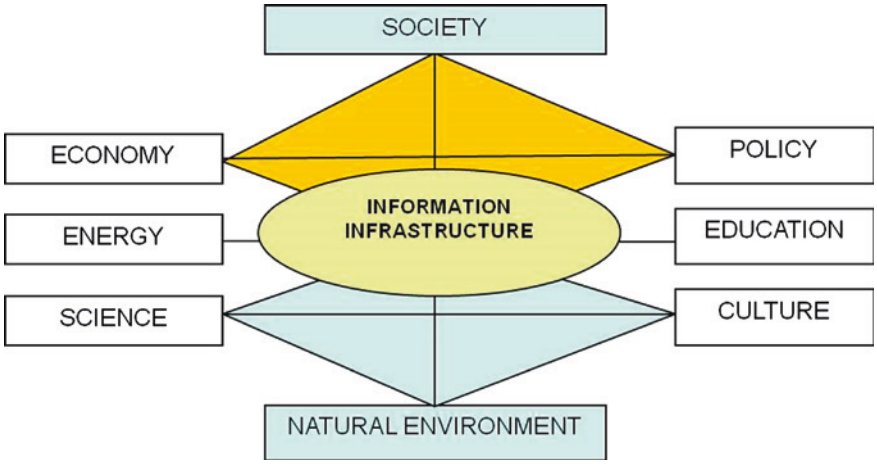

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Fig. 13.1 Impact of information infrastructure into separate segments of socioeconomic life. *Source* own

It should be noted that in systems analysis there is a "nonlinear feedback system," which brought a kind of rationality conflict that regards:

1. Time—primary effects are different from late, secondary effects;
2. Spatial and functional—what is good locally, it can be bad globally, conversely.

Globalization in the late twentieth and twenty-first centuries has brought a peculiar coincidence of these various processes, such as (Sienkiewicz and Świeboda 2009):

- economic development of transnational corporations and international investment capital inflows;
- international transfers of technology;
- development of information and communication technologies and the massification of different uses;
- dissemination of effective and standardized production of goods and services;
- development of universal and global availability of electronic media;
- rollout of universal consumer attitudes (also in the sphere of mass culture);
- creation of new sources of danger (globalization of terrorism, cyber-terrorism);
- create new dilemmas of civilization (such as globalism–alterglobalism, freedom–security).

The Evaluation of the Possible Consequences

"Foresight" includes a set of activities "that enable multidimensional determination of future social development directions, based on analysis of current state of science, technology and public awareness as well as their relationships." It is a strategic process designed to (Sienkiewicz and Świeboda 2009):

- organization of public debate on the future (prospective states) and ability to achieve the desired state through the development of science and technology;
- influence on decisions concerning development;
- creation of information resources necessary to develop medium- and long-term vision of development (development trends, investment priorities, etc.);
- gain public acceptance of public social development programs.

Identifying priorities for investment in research and development, support of absorption of technology innovations by the economy, and the reorientation of the country's scientific policy are designed, e.g., to reorient the traditional economy to the knowledge-based economy (KBE). Along particularly distinctive "foresight" of other methods and techniques of analysis and forecasting is the introduction of social dialog in order to turn on specific social groups for discussion and cooperation both with stakeholders such as representatives of science investment (R & D sector) (Sienkiewicz 2009).

"Foresight" can take place at four levels: (1) over-national, (2) national, (3) regional and local levels, and (4) industry, and includes two main stages (Fig. 13.2):

(1) identification of research areas;
(2) determination of the structure of the areas of research.

Methods include following activities:

- expert panel discussions;
- determination of the key technologies for individual panels;
- use of technology scenarios in reports creation.

It is assumed that the introduction of new technology, its modernization, or widening of the scale of appliances of existing technique causes different effects: social, economic, environmental, health, organizational, legal, etc. Therefore, the basic tasks of TA include the following activities:

- predict and determine the systematic identification and analysis of the consequences (impacts) for the latest technology;
- establish policy options to minimize the social impact of technology and comparative analysis of policy alternatives allowed (strategy);
- ensure the efficient implementation of the selected policy (strategy) (Świeboda 2009).

The general methodology of TA includes detailed analysis such as feasibility studies, market analyses, laboratory tests, analysis of the efficiency (cost-benefit, cost-effectiveness), the analysis of the impacts (environmental impact, economic impact), risk analysis, and assessment social acceptability of risk.

TA general methodology consists of the following basic steps (Fig. 13.3):

(1) problem identification,
(2) technology description,
(3) technology forecast,

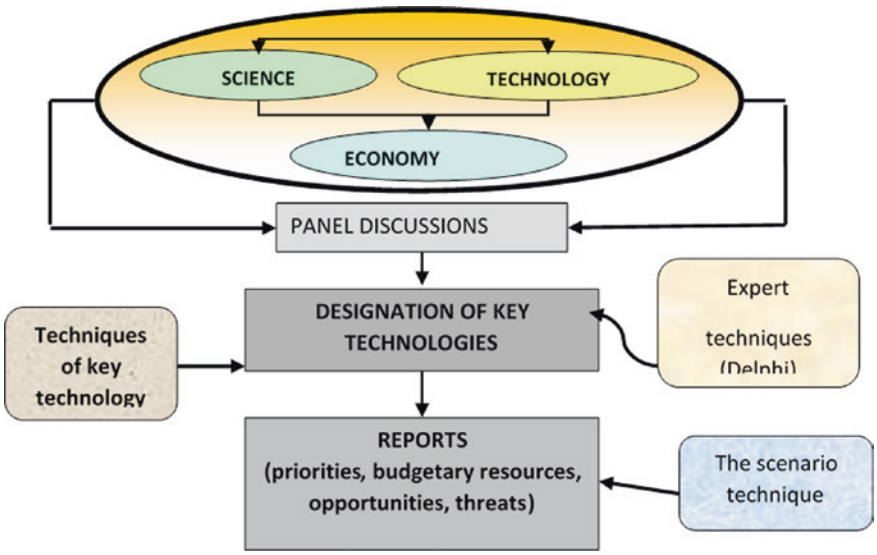

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Fig. 13.2 Methods of the "foresight" process. *Source* own

(4) social context description,
(5) social forecast,
(6) impact identification,
(7) impact analysis,
(8) impact evaluation,
(9) analysis of policy and strategic options;
(10) communication of the results.

Methodological Aspects

Suppose there is a set of acceptable technologies, each of which is characterized by a set of parameters (attributes) on the basis of which it defines a set of criteria for assessing the effectiveness (utility) formulated for the purposes of systems analysis. The problem consists in determining a strategy that is optimal for the matter accepted criteria (e.g., Pareto), i.e., that there is no strategy "better" among analyzed (Zacher 1981).

A strategy to be implemented in a specific social environment can have both desirable effects (positive and negative) and side effects. Creation of event scenarios resulting from the strategy and forecasts the development of technology leads to identification analysis of the impact (e.g., using expert techniques of "brainstorming" or Delphi, and especially computer simulation). Following step

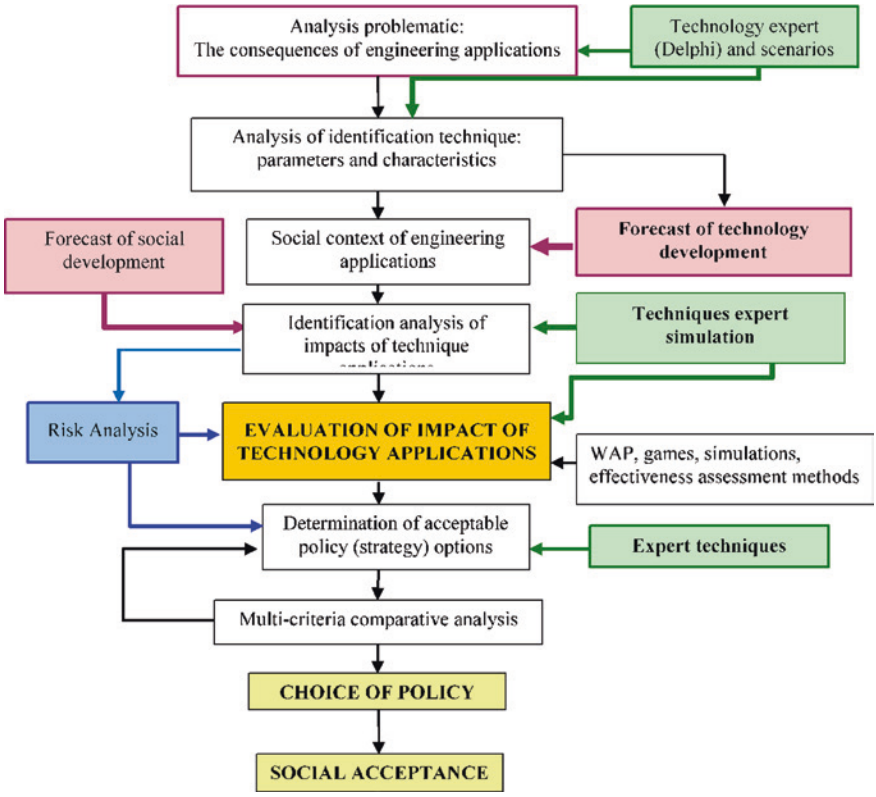

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Fig. 13.3 Methods of evaluation techniques. *Source* own

is to conduct an assessment of particular impacts with attribution of numerical values (expressing natural measures or "points"—written by the experts). The final stage of systems analysis applications (development) of a particular technology is to analyze the positive and negative effects and evaluation of its effectiveness (approval or disapproval). The assessment provides grounds of decisions such as "implement or withdraw," "upgrade or replace" ("adopt alternative technology,").

(1) The identification strategy due to the level of modern science and technology (KNOWLEDGE) and scale applications (SCALE).

Different levels of technological development ("retarded" or underdeveloped technology, developed technology, highly developed technology, advanced technology).

(2) Identification of the social environment due to the rate of economic development (quality of life) and the index of social, educational,

cultural, etc. determining the capacity of absorption and assimilation of technology, the "range of influence" (range) for the basic types of environment (underdeveloped, before to modernize, modernizing is developed, highly developed).

It is assumed that the type of technology can produce different effects depending on the type of environment in which it is used (implemented).

(3) A preliminary evaluation of the development of technology in the social environment: identify opportunities and threats to development, in particular risk assessment (as a function of opportunity and risk assessments) uses technologies such as above and a social environment (made by a team of experts using the technique of "brainstorming" or Delphi, or in the process of foresight).

(4) Identification of the social impact of technology applications:

All the possible and probable social impacts caused by the use (implementation) of the technology in a particular social environment are divided into following types (Zacher 1990):

- Key (K)—that arise from forecast and basic functions of technology (i.e., the effects of unintended use and unforeseen).
- Closer in time (B) and further (F), which may show up in the long term.

Each effect can be assessed by means of two values (e.g., utilities) benefit (B) and losses (L) or the difference between these values.

The final assessment of technology in the social environment is done with the utility of technology used in the form of, for example, composite indicator.

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